

Texasweed (*Caperonia palustris*) Control in Soybean with Postemergence Herbicides

Daniel H. Poston, Vijay K. Nandula, R. Matt Griffin, and Clifford H. Koger*

Field and greenhouse studies were conducted in 2000 and 2001 in Mississippi to determine the most effective POST herbicide programs for control of Texasweed in glyphosate-resistant soybean. In the field, Texasweed plants recovered from most POST herbicide treatments, and plant death rarely occurred. A sequential application of 1,100 g ae/ha glyphosate followed by 840 g/ha glyphosate was the only treatment that controlled at least 90% of Texasweed 4 wk after treatment. Texasweed control ranged from 80 to 87% for lower rates of glyphosate applied once or twice and 390 g ai/ha fomesafen. The addition of fomesafen or other herbicides to glyphosate did not improve control compared with glyphosate alone. In the greenhouse, glyphosate at 560 g/ha controlled 93 and 90% of one- and two-leaf plants, respectively, but at least 1,400 g/ha was required to obtain 90% control of four-leaf plants. Fomesafen at 260 g/ha controlled 93 to 99% of one- to four-leaf Texasweed plants in the greenhouse.

Nomenclature: Fomesafen; glyphosate; Texasweed, *Caperonia palustris* (L.) St. Hil; soybean, *Glycine max* (L.) Merr.

Key words: Weed control.

Texasweed is a summer annual dicotyledonous species that has emerged as a weed of economic importance in rice (*Oryza sativa* L.) and soybean grown in the lower Mississippi River Delta Region. Texasweed, a member of the family Euphorbiaceae, is an erect herb ranging in height from 30 to 300 cm (SWSS 1998). There is little information in the literature on the biology and control of this weed. Observations of weed scientists, field extension personnel, and producers indicate Texasweed tends to be more problematic in heavy clay soils typically used for soybean–rice rotations. We have observed that Texasweed emerges throughout the growing season especially in unplanted areas like wheel tracks where light is allowed to reach to soil surface. Producers have noted that glyphosate provides only marginal levels of control and that Texasweed becomes extremely difficult to control once plants have reached the four-leaf growth stage.

Infestation in soybean fields is currently restricted to only a few Mississippi Delta counties, but because this weed is difficult to control, great concern is raised about the potential spread into other areas. In addition, seed production appears to occur for an extended time throughout the growing season, with mature seed dehiscing while new seed are being produced. Koger et al. (2004) recently reported that Texasweed can germinate under a wide range of soil temperatures and pH levels, and from various soil burial depths. Texasweed plants produced an average of 893 seed per plant, and 90% of the seed were viable (Koger et al. 2004). Also, some seed float in water, making it possible for distribution via drainage systems.

The objectives of this study were to determine (1) the effectiveness of glyphosate and other POST herbicides for

control of Texasweed in glyphosate-resistant soybean, (2) whether mixtures of glyphosate with other herbicides improved control compared with glyphosate alone, and (3) the effect of Texasweed growth stage on control.

Materials and Methods

Field Studies. Three field experiments were conducted in 2000 and 2001 near Greenville, MS, in fields naturally infested with Texasweed. The soil type in both years was Sharkey clay (very-fine, smectitic, thermic Chromic Epiaquerts) with 3.0% organic matter and pH 6.4. The fields were tilled in the fall and received a burn-down application of glyphosate at 840 g ae/ha in the spring before planting. The fields were planted to glyphosate-resistant soybean in mid April. In the first experiment, glyphosate at 840 g/ha, cloransulam at 180 g/ha, chlorimuron at 9 g/ha, fomesafen at 390 g/ha, acifluorfen + bentazon at 560 + 280 g/ha, acifluorfen at 420 g/ha, acifluorfen + 2,4-DB at 420 + 35 g/ha, cloransulam + flumetsulam at 15 + 6 g/ha, imazamox at 35 g/ha, imazaquin at 140 g/ha, imazethapyr at 71 g/ha, and lactofen at 218 g/ha were evaluated for efficacy on Texasweed (Table 1). In the second experiment, glyphosate was applied alone at rates of 560, 840, 840 followed by (fb) 1,120, and 840 fb 395 g/ha, and also at the rate of 840 g/ha in combination with the following: cloransulam at 9 g/ha, cloransulam + acifluorfen at 9 + 71 g/ha, chlorimuron at 4 g/ha, fomesafen at 132 g/ha, imazaquin at 71 g/ha, imazethapyr at 35 g/ha, imazamox at 18 g/ha, and flumiclorac at 22 g/ha to determine whether mixtures of glyphosate with other herbicides improved control compared with glyphosate alone. In the third experiment, glyphosate was applied alone and in combination with fomesafen at various rates to determine whether the addition of fomesafen improved control (Table 2).

Herbicides were applied when soybeans were in the V2 to V3 stage. Texasweed was in the cotyledon- (1.3 cm) to three-

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*First, second, and third authors: Associate Research/Extension Professor, Postdoctoral Research Associate, and former Graduate Research Assistant, Delta Research and Extension Center, Mississippi State University, 82 Stoneville Road, P.O. Box 197, Stoneville, MS 38776; fourth author: Research Agronomist, U.S. Department of Agriculture–Agricultural Research Service Crop Production and Genetics Research Unit, 141 Experiment Station Road, Stoneville, MS 38776. Corresponding author's E-mail: vknandula@yahoo.com

Table 1. The effect of POST herbicides on glyphosate-resistant soybean and Texasweed in 2000 and 2001 field studies.^a

Treatment	Rate	Soybean		Texasweed		
		Injury 2 WAT		Control 4 WAT ^b	Population density 4 WAT	
		2000	2001		2000	2001
		2000	2001		2000	2001
	g/ha ^c	%			no./m ²	g/m ²
Glyphosate ^d	840	2	0	83	10	4
Cloransulam ^e	18	1	3	37	60	9
Chlorimuron ^e	9	6	11	49	120	7
Fomesafen ^f	395	13	20	80	6	5
Acifluorfen + bentazon ^f	560 + 280	9	18	72	23	5
Acifluorfen ^f	420	12	15	71	12	4
Acifluorfen + 2,4-DB ^e	420 + 35	22	20	61	25	6
Cloransulam + flumetsulam ^e	15 + 6	6	9	51	24	8
Imazamox ^e	35	7	6	51	19	7
Imazaquin ^e	140	7	2	54	36	6
Imazethapyr ^e	71	7	4	40	34	12
Lactofen ^e	218	18	13	75	12	7
Nontreated control	—	0	0	0	56	8
LSD (0.05)		3	5	11	49	5

^a Abbreviation: WAT, wk after treatment.^b Data combined over years.^c Herbicide rate expressed as g ae/ha for glyphosate and g ai/ha for all other herbicides.^d Glyphosate applied in the form of the isopropyl amine salt, Roundup Ultra®.^e Nonionic surfactant added at 0.25% v/v.^f Crop oil concentrate added at 1% v/v.

leaf (5 cm) stage in 2000 and cotyledon- (1.3 cm) to five-leaf (10 cm) stage in 2001. Herbicide applications were made with a tractor-mounted compressed air spray system calibrated to deliver a spray volume of 140 L/ha at a pressure of 270 kPa using flat fan nozzles¹ spaced 51 cm apart. Soybean injury (2 wk after treatment [WAT]) and Texasweed control (2 WAT) were determined visually using a scale of 0 to 100, where 0 was no injury or control, and 100 was plant death or

complete control. Texasweed population density and above-ground biomass was sampled randomly from a 1-m² area in each plot 4 WAT.

Plots were 12 m long with a 3-m-wide herbicide-treated area. Overall plot width varied among locations because of differences in row spacing. Row spacing was 50 cm in 2000 and 85 cm in 2001. Field studies were conducted using a randomized complete-block experimental design with four

Table 2. The effect of glyphosate, fomesafen, and glyphosate-fomesafen combinations on glyphosate-resistant soybean and Texasweed in 2000 and 2001 field studies.^a

Treatment	Rate	Soybean		Texasweed				
		Injury 2 WAT		Control 4 WAT ^b	Population density 4 WAT		Biomass 4 WAT	
		2000	2001		2000	2001	2000	2001
	g/ha ^c	%			no./m ²		g/m ²	
Glyphosate ^d	560	0	1	82	37	4	7	3
Glyphosate ^d	840	0	0	80	20	5	8	7
Glyphosate ^d	1,120	0	0	87	10	3	3	2
Glyphosate fb glyphosate ^{d,e}	1,120 fb 840	0	0	94	4	3	0	2
Glyphosate + fomesafen ^{d,e}	560 + 132	3	7	84	25	5	5	11
Glyphosate + fomesafen ^{d,e}	560 + 197	5	10	80	15	7	3	18
Glyphosate + fomesafen ^{d,e}	560 + 263	5	13	78	21	6	5	8
Glyphosate + fomesafen ^{d,e}	840 + 132	4	10	79	11	5	3	2
Glyphosate + fomesafen ^{d,e}	840 + 197	3	10	80	9	4	1	3
Glyphosate + fomesafen ^{d,e}	840 + 263	6	11	82	18	3	2	1
Fomesafen ^c	395	7	18	87	7	2	0	2
Nontreated	—	0	0	0	46	5	76	20
LSD (0.05)		1	4	11	20	3	20	13

^a Abbreviations: WAT, wk after treatment; fb, followed by, follow-up sequential applications made approximately 2 wk after initial applications.^b Data combined over years.^c Herbicide rate expressed as g ae/ha for glyphosate and g ai/ha for all other herbicides.^d Glyphosate applied in the form of the isopropyl amine salt, trade name Roundup Ultra.^e Fomesafen formulation was Flexstar HL.

Table 3. The effect of glyphosate rate and weed growth stage on POST control of Texasweed in the greenhouse.

Herbicide ^a	Rate	Growth stage				Mean
		One leaf	Two leaf	Three leaf	Four leaf	
	g ae/ha	% control				
Glyphosate	560	93	90	76	77	84
Glyphosate	840	91	91	91	83	89
Glyphosate	1,120	92	91	86	83	88
Glyphosate	1,400	95	93	91	90	92
Glyphosate	1,680	93	92	88	93	92
Mean		93	91	86	85	
LSD (0.05)		Control				
Herbicide rate		3				
Growth stage		3				
Herbicide rate by growth stage		4				

^a Glyphosate applied in the form of the isopropylamine salt, trade name, Roundup Ultra.

replications. Data were subjected to ANOVA using the PROC GLM procedure of SAS (SAS 1999), and means were separated using Fisher's Protected LSD test ($P = 0.05$). For factorial studies, ANOVA was used to test for all single-factor effects and interactions. Data were pooled over years where there was no significant year by treatment interaction.

Greenhouse Studies. Greenhouse studies were conducted to determine the effect of Texasweed growth stage and herbicide rate on the effectiveness of glyphosate and fomesafen. Mature Texasweed seed were collected just before dehiscence from plants at several field locations. Seed were stored at 1 C until use. For scarification before planting, seed were placed on the flat surface of a cement block, and a brick was lightly rolled over the seed to gently break the seed coat. Seed were placed in a greenhouse flat containing commercial potting media,² moistened, and placed on a germination mat that was set to maintain a constant temperature of 24 C. Plants in the cotyledon stage were transplanted into 11 by 11 cm greenhouse pots³ containing a commercial potting mix.³ Seeds were planted at weekly intervals over the course of 6 wk to establish size differences. Plants were thinned to one per pot and were subirrigated and fertilized⁴ once approximately 1 wk after transplanting.

Herbicides were applied to Texasweed plants in the one- (2.5 cm), two- (5 cm), three- (7.5 cm), and four- (10 cm) leaf stage. Glyphosate was applied at rates ranging from 560 to 1,680 g/ha (Table 3), and fomesafen was applied at rates ranging from 200 to 460 g/ha (Table 4). Herbicides applications were made using a moving-nozzle sprayer equipped with 8002E⁵ nozzles delivering 140 L/ha at 280 kPa.

Greenhouse studies were conducted using a randomized complete-block experimental design with four replications. Studies were repeated in time. Control was visually evaluated 17 d after treatment, and plant fresh weights were determined by removing and weighing all above ground biomass. Data were subjected to ANOVA using the PROC GLM procedure of SAS (SAS 1999), and means were separated using Fisher's Protected LSD test ($P = 0.05$). ANOVA was used to test for all single-factor effects and interactions. Data were pooled

Table 4. The effect of fomesafen rate and weed growth stage on POST control of Texasweed in the greenhouse.

Herbicide ^a	Rate	Growth stage				Mean
		One leaf	Two leaf	Three leaf	Four leaf	
	g ae/ha	% control				
Fomesafen	200	98	95	94	77	91
Fomesafen	260	99	96	94	93	95
Fomesafen	330	98	93	94	93	95
Fomesafen	400	98	98	97	96	97
Fomesafen	460	99	98	98	97	98
Mean		98	96	95	91	
LSD (0.05)		Control				
Herbicide rate		2				
Growth stage		2				
Herbicide rate by growth stage		3				

^a Fomesafen applied as Flexstar; crop oil concentrate (COC) added at 1% v/v to all treatments.

over experiments because treatment by experiment interaction was not detected.

Results and Discussion

Field Studies. Glyphosate, fomesafen, and lactofen were the most effective POST herbicides for control of Texasweed (Table 1). These herbicides provided 72 to 83% control of Texasweed, and control exceeded 80% only for glyphosate. Acifluorfen-containing treatments controlled 61 to 72% of the Texasweed, and control with other treatments did not exceed 54%. Although data were pooled over years, Texasweed control was generally higher in 2000 compared with 2001 (data not presented). This may have been because of differences in size of Texasweed because the largest plants in 2000 and 2001 were in the three- and five-leaf stage, respectively. Fomesafen, lactofen, and acifluorfen-containing treatments were most injurious to soybeans, causing 9 to 22% and 15 to 20% injury in 2000 and 2001, respectively.

Control of Texasweed consisted primarily of suppression of growth, rather than plant death. Even the most effective herbicides did not significantly reduce the Texasweed population, compared with the nontreated control (Table 1). The exception was fomesafen, which reduced population density by 89% in 2000, compared with the nontreated control. Suppression of growth was reflected in the biomass measurements, however. The most effective herbicides for control of Texasweed, glyphosate, fomesafen, and lactofen, reduced biomass by 93, 82, and 74%, respectively. Acifluorfen, imazamox, and imazaquin caused a similar reduction in biomass, which ranged from 70 to 80%. These results indicate that Texasweed is difficult to control with herbicides alone, although a combination of POST herbicides and shading by soybeans grown in narrow rows could improve control.

Texasweed control, population density, and biomass were similar when glyphosate was applied once or twice alone or in combination with cloransulam, acifluorfen, chlorimuron, fomesafen, imazaquin, imazethapyr, imazamox, or flumiclorac

(data not shown). A single application of glyphosate at 840 g/ha controlled 84% of Texasweed and reduced population density by 79% and biomass by 95% compared with nontreated control (data not shown). These results indicate that making a sequential glyphosate application at 560 g/ha or tank mixing other herbicides with glyphosate may not improve Texasweed control or reduce density or biomass.

Texasweed control was similar when glyphosate and fomesafen were applied alone or in combination (Table 2). These herbicides provided 78 to 87% control of Texasweed. The most effective control (94%) resulted from two applications of glyphosate. In 2000, Texasweed population density was reduced 47% or more by all treatments, with the exception of glyphosate at 560 g/ha, which did not reduce population density compared with the nontreated control. In 2001, effect of most herbicide treatments on Texasweed was difficult to measure because of low weed density. Glyphosate and fomesafen, when applied alone or in combination reduced Texasweed biomass 89 to 100% in 2000. In 2001, herbicide treatments reduced Texasweed biomass by 65 to 95%, with the exception of combinations of fomesafen with glyphosate at 560 g/ha, which reduced biomass by 10 to 60%.

Greenhouse Studies. Texasweed biomass was reduced by 90% or more regardless of glyphosate rate or Texasweed growth stage (data not shown). Texasweed control, based on visual evaluations, was affected by both glyphosate rate and Texasweed growth stage (Table 3). Texasweed control, averaged over glyphosate rates, decreased from 93 to 85% as the plant size increased from one leaf to four leaves (Table 3). Also, Texasweed control, averaged across plant size, increased from 84 to 92% when glyphosate rate increased from 560 to 1,680 g/ha. A glyphosate rate of a least 1,400 g/ha was required to obtain 90% or greater control of four-leaf plants. These results suggest that 1,400 g/ha glyphosate is required for effective control of plants that have reached the three-leaf stage.

At least 93% Texasweed control was obtained with fomesafen, regardless of rate or Texasweed growth stage (Table 4). The exception was fomesafen at 200 g/ha applied to four- (10 cm) leaf tall Texasweed, which controlled 77% Texasweed. Texasweed control, averaged over fomesafen rates, decreased from 98 to 91% as the plant size increased from one and four leaf (Table 4). Also, Texasweed control, averaged

across plant size, increased from 91 to 97% when fomesafen rate increased from 200 to 460 g/ha. A fomesafen rate of 200 g/ha is adequate to obtain 93% or greater control of three-leaf Texasweed plants, but all fomesafen treatments reduced biomass by at least 89% (data not shown).

In summary, Texasweed plants in the field recovered from most POST herbicide treatments, and plant death rarely occurred. Largest Texasweed plants were three- (5 cm) leaf in 2000 and five- (10 cm) leaf in 2001. In the greenhouse, glyphosate and fomesafen adequately controlled three- (7.5 cm) leaf Texasweed, but not when plants were at four- (10 cm) leaf stage. The level of Texasweed control seen in the greenhouse may not be achievable in the field. These results indicate that Texasweed is difficult to control with herbicides alone, although a combination of POST herbicides and shading by soybeans grown in narrow rows could improve control.

Sources of Materials

¹ Teejet XR11002VS flat fan nozzle, Spraying Systems Company, North Avenue, Wheaton, IL 60118.

² Pro-Mix BX, Premier Horticulture, Inc., 127 South 5th Street, Red Hill, PA 18076.

³ Dillen 4.25-in. square pots, inside dimensions of 10.8 by 10.8 by 9.5 cm, Dillen Products, 15150 Madison Rd., Middlefield, OH 44062.

⁴ Excel All Purpose 21-5-50, Wetzal, Inc., 1345 Diamond Springs Road, Virginia Beach, VA 23455.

⁵ Teejet 80015E stainless steel flat fan tip, Spraying Systems Company, North Avenue, Wheaton, IL 60188.

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